THE ABSOLUTE MAGNITUDES OF NOVÆ

By Knut Lundmark

It seems to be a rather common conception that novæ before the outburst, have been very cool stars, of low luminosity, and that the absolute magnitude even at maximum may not have been very high. But several facts indicate distances for the novæ such that we must assume the maximum luminosity to be higher than the luminosity for any other class of stars.

(1)   The novæ are typical Milky Way objects and form a very flattened galactic system. This fact generally seems to be a good indication of considerable distances for the objects in question.

(2)   The novæ seem to be related to dark nebulosities in our stellar system as shown in these Publications, volume 33, pages 219, 225, 314, 1921. An attempt has been made[1] to derive the parallaxes for a number of dark nebulæ with the result that they correspond to distances of several hundreds or thousands of light years.

(3)   A quantitative means for estimating the distances of novæ is afforded by existing data for proper motions. Values for the motions are now known for 11 novæ. It is quite possible that future researches will modify the individual values, but it is thought that the mean proper motion is fairly well established from the material at hand. The mean value of the 11 motions is 0″.011 and the largest value is 0″.021 (for Nova Geminorum No. 2). The material has been used for a determination of the apex and the following results have been obtained.

A=150° ; D=−16° ; parallactic drift =0″.0052.

As well known, it is very hard to say how much of the observed displacements of lines in novæ spectra is due to motion in the line of sight. Still it seems likely that the radial velocities for novæ are more or less of the same size as for ordinary stars (compare Adams' results from certain fine absorption lines). We have assumed the value of 21.5 km/sec for the

[1]These Publications, **34**, 40, 1922.

velocity of our Sun relative to the novæ, which gives a mean parallax of 0″.0011 and a mean maximum magnitude of —7.1 for the 11 objects investigated.

The considerable deviation of the novæ apex from that generally adopted (A=270°, D=+30°), may be due to a real difference in systematic motion between the novæ and the neighboring stars. It may also be partly explained by incomplete elimination of the motions of the comparison stars. If we have a number of distant objects where the derived proper motions only reflect the proper motions of the comparison stars it can be shown that Airy's method will give the co-ordinates of the antapex as the result. Our apex obtained for novæ is really situated in the direction of the antapex, although at a considerable angular distance therefrom, which may possibly indicate that the proper motions of the novæ have not been freed from the motions of the comparison stars.

Using the ordinary solar apex and computing the mean parallax from the upsilon components we get $\pi=0″.0002$, and — 10.8 as the mean maximum magnitude.

(4)   As shown before[1], the novæ are not uniformly distributed in galactic longitude. In fact, a number of novæ seem to be related to the distant center of our Milky Way system. From Shapley's work the distance to the center is determined as 20000 parsecs. If we assume the novæ in the Sagittarius-Scorpius region to have a mean distance corresponding to Shapley's value, we find —9.0 for the mean absolute magnitude of the novæ.

The three different methods have given the following mean values for the maximum magnitude M max.

	M max
(1)	— 7.1
(2)	—10.8
(3)	— 9.0
Mean	— 8.5

The following table gives a resumé of what is known about the parallaxes and absolute magnitudes of *individual* novæ.

[1]These Publications, **33**, 219, 231, 1921.

| Nova | Parallax | | | |
	Trigono- metric	From Spectrum	Hypothetical	Adopted
Persei	0″.0100		0″.0093	0″.0095
Aquilæ No. 3 . . . . {	0 .006		0 .006	0 .006
{	(0 .014)			(0 .014)
Geminorum No. 2.	0 .005			0 .005
Lacertae	0 .006			0 .006
P Cygni	0 .003			0 .003
Scorpii 1860			0 .00006	0 .00006
T Coronæ		0″.0014	0 .0012	0 .0013
Aquilæ No. 4		0 .0003		0 .0003
RT Serpentis		0 .003		0 .003
η Carinæ			0 .0015	0 .0015

| Nova | Magnitude | | | |
	m max	m min	M max	M min
Persei	0.0	13–15	—5.1	8–10
Aquilæ No. 3	—1.2	10.5	—7.3	+4.4
. .			(—5.5)	(+6.2)
Geminorum No. 2.	3.7	13.5	—2.8	+7.0
Lacertae	5.0	14.5	—1.1	+8.4
P Cygni	3.0	4.9	—4.6	—2.7
Scorpii 1860	7.0	?	—9.1	?
T Coronæ	2.0	9.6	—7.4	+0.2
Aquilæ No. 4	?	12.5	?	0.0
RT Serpentis	?	15.0	?	+7.4
η Carinæ	1.0	8.5	—7.0	+0.6
			Mean —6.2	

REMARKS

(a) *Nova Persei.* 6 determinations of the parallax exist, viz., + 0″.026 ∓ 0″.010 by Bergstrand; + 0″.005 ∓ 0″.004 by Küstner; +0″.020∓0″.030 by Hasenstein; +0″.007∓0″.004 by van Maanen; —0″.012∓0″.023 by Chase and —0″.010 by Hartwig. The parallaxes derived in the table are absolute values and systematic corrections to the system of van Maanen and Miss Wolfe have been applied. Several determinations of the hypothetical parallax of this star have been made on the assumption that we have seen the light reflection of the outburst in the nebular phenomena observed around the nova. The most recent value of the parallax derived by this way is Turner's, giving $\pi=0″.0093$. The close agreement between the two values must be taken as a strong argument in favor of the reality of the derived parallax, a view also confirmed by the size of the proper motion and other observational facts.

(b) *Nova Aquilæ No. 3.* The following trigonometric

determinations of the parallax have been published: $+0''.019$ $\mp0''.006$ by van Maanen; $-0''.001\mp0''.008$ by Daniel; $-0''.015\mp0''.008$ by Olivier; $+0''.071\mp0''.013$ by Courvoisier; $+0''.197\mp0''.050$ by Philipot and $+0''.064\mp0''.072$ by Delporte. Using all values we get the absolute reduced parallax as $+0''.014$ but it seems reasonable to exclude the three last values as depending on meridian circle observations. As shown by Henroteau the large positive parallax by Philipot can be reduced to a negative one when the proper motion is introduced in the solution. Of course, the actual proper motion is very small and the large value resulting from Philipot's material is rather to be interpreted as a magnitude equation.

The three photographic determinations give $+0''.006$ for the absolute parallax, in exact agreement with the value derived by me by comparing the expansion in angular and linear speed of the nebulous disk. The upsilon component seems to be principally a reflex of the Sun's motion and gives the same value for the parallax.

(c) *Nova Geminorum No. 2.* Two directly measured parallaxes have been published, viz., $+0''.006\mp0''.008$ (Slocum) and $-0''.019\mp0''.013$ (Miller).

(d) *Nova Lacertæ.* Two measured parallaxes exist, $+0''.007\mp0''.012$ (Slocum and Mitchell) and $-0''.005\mp 0''.020$ (Balanowsky).

(e) *Nova P Cygni.* Slocum and Mitchell measured the parallax: $-0''.021\mp0''.016$.

(f) *Nova Scorpii 1860.* This nova appeared very close to the center of the globular cluster M 80. Although very little is known about this object it seems to be a *bona fide* nova as the extensive watch of this region by Schmidt and other observers excludes the possibility of its being a variable of another type. If we assume the nova to be actually connected with the globular cluster, we find from Shapley's parallax a value of M max—9.5 and from Lundmark's —8.7 or in the mean —9.1.

(g) *Nova T Coronæ.* See the note in this issue.

(h) *Nova Aquilæ No. 4.* According to spectrograms obtained by me at the Lick Observatory this star has a spectrum

corresponding to the type Ro[1] and of giant character. An absolute magnitude of 0.0 has provisionally been assumed in accordance with the mean value for R-type stars as derived by Laplau, Janssen and Haarch.

(i) *Nova RT Serpentis.* Adams, Miss Burwell and Joy have determined the absolute spectroscopic parallax at $0''.003$.

(j) *Nova η Carinæ.* For the key-hole Nebula a parallax of $+0''.0015$ has been derived in these Publications, **34,** 40, 1922. If we assume the nova to be connected with this nebula, we get the absolute maximum magnitude as given in the table, a value in harmony with the size of the upsilon component.

From the table and from what is said about the mean parallax of novæ we see that at maximum they have in the mean an absolute magnitude surpassing the values for any other class of stars. Very little doubt can exist as to the reality of the parallaxes and magnitudes derived for Nova Persei, Nova Aquilæ No. 3, and Nova T Coronæ. The apparent magnitudes for these stars before outburst are also known and indicate that *novæ probably originate both from giant and dwarf stars.* Attention is also called to the interesting fact that although the spectrum of Nova Persei now undoubtedly is that of a Wolf-Rayet star, the absolute magnitude is extremely low.

In view of this fact and of the very common occurrence of novæ, if we deal with "astronomical" epochs, it seems probable that most of the stars have actually passed through the nova stage. Bailey has found that, conservatively estimated, more than nine novæ brighter than 9^{m} at maximum appear every year. After a few million years the number of novæ will be as great as the number of stars brighter than, say, 17th magnitude. Of course, it is quite possible that the same star passes the nova stage several times, but even so the number of old novæ among the known stars must be enormous. In the future, novæ may come to be considered not as exceptions, but as marking a stage through which the majority of the stars pass.

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[1]For further details see these Publications **33,** 314, 1921.